

ins
a1

COMPUTER PROGRAMMING LANGUAGE
STATEMENT BUILDING AND INFORMATION TOOL

FIELD OF THE INVENTION

5 This invention relates to the field of computer programming tools and in particular to an intelligent real time tool to assist a computer programmer during the writing, evaluation, and/or maintenance of a computer program.

PROBLEM

Two related problems exist in the field of computer programming that
10 include, but are not limited to, generating a computer program quickly and accurately on a first attempt, and maintaining a computer program with a minimal amount of effort once a computer program exists. The two related problems exist due to many factors that include, but are not limited to, the increasing complexity of computer programs generally, the architectural
15 modularity of computer programs, and the increasing distribution of programmers that are contributing to a common program across campuses, countries, and even continents. Each of these factors places a premium on the efficiency of a programmer whose role is to develop and/or maintain a computer program.

20 It is a problem for a computer programmer to generate a computer program in a high level programming language quickly and accurately on a first attempt. To generate a large and/or complex computer program, the programmer must be able to enter computer programming language statements quickly and accurately in a traditionally manual process that is also referred to as
25 "writing code" or "coding". The process of entering computer programming language statements is typically done one keystroke and one statement at a time by way of a typewriter style keyboard input system that commonly accompanies most computing systems.

As a computer program evolves during the coding process, accuracy
30 becomes a particular problem due in part to the arcane syntax of programming languages in addition to the often cryptic grammar and/or spelling that is characteristic of programmer-declared object entities in a computer program, such as variable names, parameter names, structure names, structure members, object names, object property types, and the like. Not only must

references to a declared entity be spelled correctly, the declared entity must also be used in the correct context and syntax if the resulting computer program is expected to compile without errors and/or execute as intended.

Examples of commercially available and widely used programming languages include, but are not limited to, object oriented programming languages such Visual Basic or C++. Object oriented programming languages, as with most traditionally used high level programming languages, contain types of programming language statements that can be grouped into two basic categories. The basic categories include, but are not limited to, operator embedded statements and procedure calls. For example purposes only, object oriented programming language examples are the focus of the remaining discussion.

An operator embedded statement includes at least one defined *object entity* that is used with varying combinations of unary, binary, and/or assignment operators. An object entity is a basic building block of an object oriented programming language statement and typically includes a hierarchical object name and member name format such as the following:

<object name> <operator> <member name>

where *<object name>* and *<member name>* are discrete hierarchical segments of an object oriented programming language structure. An *<operator>* is a character defined by the programming language syntax that in the present example separates, delineates and/or indicates a syntactic relationship, between an object and a member of the object. Common examples of these delimiting type operator characters include the dot "." and the pointer "->" characters, in addition to the parenthesis "(" and the square brackets "[".

There are typically multiple objects defined in an object oriented computer program, any one of which can be used for the *<object name>* segment of a programming language statement. For any given object identified by *<object name>*, there can be multiple members and/or levels of members that can be validly used for the *<member name>* segment of a programming language statement. A named member is often referred to as a property or method. A valid combination of *<object name>* and *<member name>* together define an object entity that may be of any type including, but not limited to, a variable of

some data type, a symbolic constant of some data type, or an array or structure or union, or any portion thereof.

Sets of *<object name>* and *<member name>* object entities can be separated by or used in conjunction with operators that can include, but are not limited to, logical, bitwise logical, relational, arithmetic, or character manipulation operators, from the well known sets of unary, binary, and assignment operators that are common among programming languages. Unary, binary, and assignment operators can include the above identified delimiter operators in addition to any one or combination of the set of characters {=, +, *, ^, !, <, >, /}. One example of object entities used in an expression is the following simple assignment statement:

<object name> . *<member name>* = *<value>*

where *<value>* is some object entity or constant having a data type that is compatible with the object entity defined by *<object name>* and *<member name>*. Another example of object entities used in an expression can include::

<object entity 1> = *<object entity 2>* + *<object entity 3>*

However, with any of the above exemplary constructions of programming language statements, in addition to the variety of constructions not shown herein, at least one object entity must be constructed somewhere within the programming language statement. It is the construction of even one object entity that presents the opportunity for typographical errors, incorrect syntax, and other human programmer introduced problems.

Another fundamental category of programming language statement is the procedure call, also referred to as a function call. A procedure call can, but is not required to, include at least one argument in an argument list. The terms argument and argument list are often used as synonyms with and/or mixed and matched with the terms parameter and parameter list. For purposes of this discussion the terms argument and argument list are used. An argument is another type of object entity in a programming language. The basic format of a procedure call typically includes a procedure name followed by a comma-separated argument list within parentheses as follows:

<procedure name> (*<argument 1>*, . . . , *<argument n>*)

The argument list may include mandatory or optional arguments or no

arguments at all. If no arguments exist the parentheses may be present but empty or the parentheses may not exist at all. An argument can be an individual object entity or an expression as discussed above with embedded operators, or the argument can itself be a procedure call or an object having a selection of members to choose from. A common requirement of nested procedure calls is that the return value of the lowest level nested call must be returned so that a value exists for the argument that is the procedure call.

However, regardless of the number of arguments or the type of argument in an argument list for a given procedure call, each argument must resolve to a value of a specific type that is compatible with the argument definition. Further, each value for each argument must be located in a specific position in an argument list to avoid errors. It is the procedure name and the type, order, and mandatory or optional nature of arguments for the procedure that present numerous opportunities for typographical errors, incorrect syntax, and other human programmer introduced problems.

The difficulty in writing programming language statements is that the programmer must remember the statement syntax in addition to the spelling of and selection of the member names that correspond to the named object. Even if the same programmer is declaring and later referencing an object or member name, it can be easy to forget the exact spellings when there are hundreds of objects and members named in a complex program. This problem is even more pronounced where one programmer names an object and another programmer is expected to remember the cryptic name definition in an environment where the two programmers may not even know each other and may even be in different countries. Thus, in either case if a programmer can not remember either the syntax, spelling, or selection options that are necessary to complete a given programming language statement, then the programmer must stop and either look up the information in an on-line help system, printed manual pages, or consult a helpful co-worker who may know the answer. However, the result of having to stop to look up information is disruptive and very inefficient.

One solution to the above stated program generating problem is to simply enter programming language statements as rapidly as possible with little concern for precision of syntax, spelling, or selection options. Once some

number of programming language statements have been entered, the program can be compiled to use the compiler as a filter to flag syntax, spelling, and option errors or incompatibilities. The programmer can then make an error correcting pass through the computer program to correct each error flagged by the compiler and repeat the error filtering process as many times as is necessary until the program is complete. However, this error filtering approach is extremely inefficient and has the potential to introduce large quantities of errors that can be difficult to distinguish in an overwhelming cascade of compiler errors. Further, some errors may escape the compiler altogether, only to be discovered as run time errors or logic errors.

It is also a problem for a computer programmer to maintain a computer program, or portion thereof, that was written by another programmer or was written by the same programmer long enough ago that specific details may have been forgotten. This is a particular problem in large and/or complex programs. In either case it is necessary for the maintaining computer programmer to become quickly familiar with all aspects of the maintained program. This means that the programmer must look up all structures, names, argument lists, choices, variables, and declared constants that are used in the body of a program which can take hours or days of searching depending on the complexity of a program and availability of information. Thus, working through unfamiliar computer programs can be a difficult and time consuming task.

Existing programming language coding techniques rely on a programmer's attention-to-detail, ongoing access to reference materials, peer code reviews, and other inefficient methods, none of which lend themselves to generating and/or maintaining large amounts of complex programming language code with any level of efficiency and accuracy. For these reasons, there exists a long felt need for a programming tool to assist the programmer in writing and/or maintaining a computer program accurately and efficiently. Such a solution has heretofore not been known prior to the disclosure set forth and claimed below.

30 SOLUTION

The above identified problems are solved and an advancement made in the programming tool field by the computer programming language statement building and information tool of the present invention. The present invention

generates assist windows that contain program related information for use by a programmer to construct a programming language statement and/or to obtain real time information about a programming language statement. Constructing a programming language statement is a process referred to as statement building.

- 5 The assist windows can be automatically displayed as determined by the tool itself. Alternatively, and/or in combination with the automatic features, a programmer can manually request that an assist window be displayed on demand. The automatic display feature can be enabled and disabled independent of and without inhibiting the manually requested assist window display feature of the present invention.

An assist window displays two general categories of information including, but not limited to, selection menu information, and informational display. One important feature of the statement generating tool is that assist windows are non-intrusive and can be ignored by the programmer by merely continuing to type an immediate programming language statement at a present character position cursor location without interacting with the assist windows. The assist windows continue to appear, disappear, and/or update in a location proximate to but out of the way of the present character position cursor location so long as the automatic assist window display feature is enabled.

- 20 Selection menu information in an assist window includes any finite list of previously declared entities and/or entity types that can validly be included at the present character position cursor location in a programming language statement.

A selection menu includes at least one menu item. The set of the at least one menu item in a given selection menu is defined by the portion of the programming language statement that immediately precedes the present character position cursor location. A menu item being displayed in a selection menu can be accepted by the programmer in a manner that results in the selected menu item being automatically inserted into the immediate programming language statement at the present character position cursor location without the programmer having to type any or all of the characters of the selected menu item. Thus, a selection menu assist window supplies information about a programming language statement and the ability to build all or part of a programming language statement in a manner that the programmer can use or

ignore individually or in combination according to the programmer's immediate needs.

The content of an informational display assist window can include, but is not limited to, a map of the argument list options for a procedure call that is identified by the present character position cursor location, specific values associated with defined constants in a programming language statement, and general programming language statement help information. For example, an argument list for a procedure call can include a highlighted argument that indicates the present character position cursor location within the argument list.

The argument list may also include individual font, typeface, or additional characters to distinguish between mandatory and optional arguments within an argument list. The informational display assist window displays procedure call arguments in argument list order accompanied by any options that may exist for each argument in the list. An individual argument that requires or will accept a previously defined entry, may be selected from an overlapping selection menu as previously disclosed. Specific argument information can include, but is not limited to, a name, type, selectable value, and/or default value.

50970409-100304
SUBB The information provided within any of the above identified assist windows supplies the programmer with just enough information to complete the immediate segment of a programming language statement without having to enter additional characters to complete of the programming language statement, and without having to pause and consult notes or manual pages, or to recall details, to decide what segment of the programming language statement is required next. The result is increased programmer productivity due to the accuracy and speed in which programming language statement can be produced on a first attempt. This advantage is realized for a single programmer who is generating all modules or objects of a computer program alone, and more particularly when multiple programmers are each separately generating a few modules or objects in a very large and/or complex software system where one programmer has no idea of the spelling or selection of named entities defined by another programmer.

Automated assist windows appear based on a determination of the possible choices that exist in view of the programming language statement

09970409-100001
FOUO

- characters and/or identifiers immediately preceding the character position cursor. A continuous high-level compilation occurs as each character in each line of programming language code is entered so that symbols, labels, and names can be instantly resolved for the immediate programming language statement whether the defined entity being referred to is a local program definition or a global library definition. Alternatively, manually invoked assist windows appear on demand based on a user request. The information displayed in an assist window is determined by first parsing the programming language string proximate to the present character position cursor. From the tokens of the parsed programming language string, the system then determines the type of programming language statement that exists, and any information that might be displayed about the immediate programming language statement. In the preferred embodiment the parsing is done as a reverse parse, however, any parsing technique can be used.
- The statement generating and information tool is operable in any computing environment in the range of environments from a personal computer to a workstation and mainframe, provided that the computing environment supports a programming language compiler either directly or by way of a network connection. In a typical embodiment the computing environment is a general purpose personal computer having a windows based operating system and programming language compiler running on a typical processor that is operatively attached to a input/output devices including but not limited to a display screen, keyboard, and mouse.

BRIEF DESCRIPTION OF DRAWINGS

- FIG. 1 illustrates a block diagram of an exemplary computing environment in which the present invention can be implemented;
- FIGs. 2-6 illustrate a stepwise progression of selection menu assist windows in screen display form;
- FIGs. 7-9 illustrate a stepwise progression of informational display assist windows in screen display form;
- FIG. 10 illustrates an overview of the assist window operational steps in flow diagram form;
- FIG. 11 illustrates an overview of the automated assist window

operational steps in flow diagram form;

FIG. 12 illustrates details of a commit key operation in the context of the automated assist window operational steps in flow diagram form; and

FIGs. 13A and 13B illustrate an overview of the manually requested assist window operational steps in flow diagram form.

DETAILED DESCRIPTION

Exemplary Computing Environment - FIG. 1

FIG. 1 illustrates a block diagram example of a general purpose computer system 100 that is suitable for use with the present invention. However, the present invention is operable in any of the several computing environments that can include a variety of hardware, operating systems, and program modules that are all commercially available in the industry. Program modules include, but are not limited to, routines, programs, components, data structures, and the like that perform particular tasks and/or implement particular abstract data types.

Moreover, persons skilled in the art appreciate that the invention can be practiced with other computer system configurations including, but not limited to, hand-held devices, network computers, multiprocessor based systems, microprocessor-based or other general purpose or proprietary programmable consumer electronics, minicomputers, mainframes, and the like. The present invention may also be practiced in distributed computing environments where tasks are performed by remote processing devices that are linked through communications networks. In a distributed computing environment, program modules may be located in and/or executed from local and/or remote memory storage devices.

The present invention and any other necessary programmed instructions and/or commands are executable on processor 102. Processor 102 stores and/or retrieves programmed instructions and/or data from memory devices that can include, but are not limited to, Random Access Memory (RAM) 110 and Read Only Memory (ROM) 108 by way of memory bus 152. Another accessible memory device includes non-volatile memory device 112 by way of local bus 150. User input to computer system 100 is entered by way of keyboard 104 and/or pointing device 106. Human readable output from computer system 100 can be viewed on display 114 or in printed form on local printer 115.

Alternatively, computer system 100 is accessible by remote users for purposes that can include debugging, input, output and/or generating human readable displays in printed and/or display screen output form, or any other output form, by way of a Local Area Network (LAN) or Wide Area Network (WAN) 116.

5 Selection Menu Assist Windows - FIGs. 2-6

FIGs. 2-6 illustrate a stepwise progression of display screen snapshots for an operator embedded programming language statement that is being constructed by a programmer using a typical object oriented programming language. The type of assist window most commonly used to facilitate the construction of an operator embedded programming language statement is called a selection menu assist window. The examples discussed and/or referred to in this document are generic object oriented programming language statements. However, the present invention can be implemented within the structure of any programming language and no limitation is intended or implied by the object oriented examples herein.

A selection menu assist window itself, as with any type of assist window, is the visual user interface component that makes the present invention particularly useful to a programmer who is generating, modifying, or reviewing a computer program. A selection menu is a drop-down style window that is a common window user interface feature. A drop-down window is also known as a pop-up menu or pop-up window, and typically includes standard window features such as overflow text slide-bars, default selection highlighting, random pointing device menu manipulation and selection control, and keyboard directional arrow key menu manipulation and enter key selection control.

A selection menu assist window displays a finite list of syntactically valid menu items that are based on previously defined object entities. Each menu item in a given selection menu assist window is also only applicable to the immediate section of the programming language statement that is proximate the character position cursor on the programmer's display screen. Choosing from the finite list of menu items saves the programmer from having to independently recall the list of valid possibilities that can be used to complete an immediate section of a programming language statement. Choosing from the finite list of menu items also saves the programmer from having to manually enter each

keystroke of an immediate section of a programming language statement and minimizes the chances that the programmer might inadvertently enter a typographical error into a programming language statement.

5 A menu item from a selection menu assist window is used to build part of a programming language statement if the menu item has been *selected* and *committed*. A menu item is said to have been *selected* if menu item for use in the immediate programming language statement by way of a windows based screen pointing device such as a mouse for example, or by positioning a present menu item indicator bar such as a highlight bar over the desired menu item
10 using keyboard directional keys. Accepting a highlighted selection, also known as *committing*, is accomplished by engaging any one of a set of predefined *commit keys* such as a {Space} or {Enter} key, or the dot "." character. The set of predefined commit keys includes any character that functions as a delimiter in a programming language statement and is programming language specific.
15 Common delimiter type commit keys can include, but are not limited to, {Enter}, {Space} and any one of the set of {.,(),+,*^<>:|}. In the context of the present invention, a commit key serves no commit function at all if the selected menu item is not also highlighted. The assist window can be removed from view on the display screen by pressing the {Escape} key or by moving the character
20 position cursor.

A menu item in a selection menu can also be entered into a programming language statement by anticipation typing a sufficient number of characters to uniquely correspond to only one menu item. When enough characters are entered for an exact match, the corresponding menu item is automatically used
25 to replace the immediate section of the programming language statement when a commit key is entered. Regardless of the type of entities listed in the selection menu, a selection menu assist window is displayed in a preferred embodiment proximate to the present character position cursor location. The contents of a selection menu assist window is determined by reverse parsing and/or
30 continuous partial compiling of the existing program and that portion of the programming language statement fragment that precedes the character position cursor.

FIG. 2 illustrates an example of a programming language edit display

5 window 200 as it might appear at time T1 on the display screen of a personal computer. For purposes of this example, assume that a programmer is writing a computer program comprised of programming-language statements 201 that, among other things, define an object having the name *mytext* as a standard
10 TextBox type supported by the programming language. The object of the present discussion is the programming language statement 210 that begins with the member name *mytext* 211. The operational purpose of programming language statement 210 is to change the font of the object *mytext* 211 into underlined text. Fig. 2 illustrates the time when the programmer has typed the
15 characters *mytext* 211 in the programming language statement 210 so that the character position cursor 202 is at the character position following the last character of *mytext* 211.

FIG. 3 illustrates the programming language edit display window 200 from FIG. 2 at a new time T2. At time T2 the programmer has typed the member
20 access separator character 212, in the present case the dot "." character, following the last character of the object name *mytext*. In response to typing the member access separator character 212, the statement building tool of the present invention determines the set of menu items that correspond to the object type *mytext* and a selection menu assist window 220 is displayed proximate the
25 present character position cursor 202. The selection menu assist window 220 contains a set of menu items 221-227, any one of which can be validly included in the present programming language statement at the immediate location of character position cursor 202. Each of the set of menu items 221-227 has a member type, such as a *property* member type, a *method* member type, or a
30 *constant* member type. The member type for a given menu item is identified by a bitmap that is adjacent to the menu item. For menu item 221 for example, there exists a bitmap 230 and a member name 231 of *Alignment*. The member type for each of the set of menu items 221-227 in the FIG. 3 example are all a *property* type. The member name 231 is the present menu item as identified by the present menu item indicator 223. The present menu item indicator 223 notes the present menu item from among the set of visible menu items 221-227 by a broken line enclosure.

The programmer can scroll through the set of menu items 221-227 using

either the standard keyboard directional keys {Up}, {Down}, {Page Up}, and {Page Down}, or by using the window scroll buttons 240-241 and/or scroll bars 242. Note that the selection menu assist window 220 is only large enough to display the set of menu items 221-227 and that the purpose of the scroll feature is because at least one more menu item might exist outside the immediate view of the present window and the menu items must be scrolled up or down to see any out-of-view menu items. Committing one of the set of menu items 221-227 is accomplished by pressing the {Control-Enter} or {Tab} keyboard keys when the desired menu item is highlighted, or by double clicking the desired menu item using the selection button on a screen pointing device. In either case, the selected menu item is inserted into the programming language statement 210 from the present location of the character position cursor 202. Any text between the last delimiter and the character position cursor is replaced by the menu item.

FIG. 4 illustrates a second set of previously out-of-view menu items 410-416 at a time T3 within selection menu window 220. The previously out-of-view menu items 410-416 are revealed by either the traditional scrolling methods as previously disclosed, or by anticipation typing as disclosed below. Anticipation typing is useful in the situation where the programmer knows the name or at least the first character of the desired menu item and causes the desired menu item to "scroll" into view by typing at least the first character of the desired menu item.

Starting from FIG. 3, the programmer can view the set of menu items 221-227 in selection menu assist window 220. Without moving from the traditional touch typing hand position, the programmer can enter the character "f" 420 at the present character position cursor location 202, which results in an automatic search of the complete set of menu items 221-227 and 410-416 to locate the first menu item in the alphabetic list that begins with the character "f" 420 otherwise no scrolling occurs. FIG. 4 illustrates the result of the automatic search.

The highlighted menu item 410 is the first menu item in the complete set of menu items that begins with the character "f" 420. Although there are other menu items 413-416 that begin with the same character, only the first in the list is highlighted. The highlighted menu item 410 is the selected menu item that

removed from the programming language edit window 200 at any time by pressing the {Escape} keyboard key or by horizontally moving the character position cursor.

If the statement building tool does not identify an exact menu item match from the anticipation typed characters input by the programmer, then the resulting narrowed list of menu items assist the programmer in quickly identifying and selecting the desired menu item by way of the scrolling and selection methods previously disclosed. However, the best alphabetic match can be committed by pressing the {Ctrl-Enter} or {Tab} keyboard keys. For example, if the programmer had typed the characters *fontbl* as the anticipation typing characters in programming language statement 210 of FIG. 4, the selection menu assist window 220 would scroll to and lowlight select menu item 411 *FontBold* as the present menu item having the best available alphabetic match. The present menu item 411 can then be committed by pressing a non-delimiter commit key such as the {Tab} keyboard key. A delimiter type commit key can not be used because the present menu item is a lowlight selection and a commit by way of a delimiter character requires a highlight selected menu item. Requiring the highlighted selection requirement facilitates the programmer's ability to type-through any assist window.

FIG. 5 continues the present example at a time T4 by assuming that the programmer has used the delimiter commit key dot "." 511 to accept the menu item *Font* 510 into programming language statement 210. Thus at time T4, the statement building tool automatically determines by way of continuous partial compiling, that the incomplete programming language statement *mytext.font* is an object of the *Font* type and that a second selection menu assist window 530 is required to display a new set of menu items 531-537 that correspond to the previously defined *Font* type object. The programmer can select one of the set of menu items 531-537 in a manner as previously disclosed in the text accompanying FIG. 4.

FIG. 6 illustrates that *Underline* 610 was committed as part of programming language statement 210 by using the delimiter commit key equal "=" 611. Once the programming language statement 210 is completed up to the present character position cursor location 202 in FIG. 6, the statement building

position of the character position cursor 732 within the argument list.

In the FIG. 7 example, the first argument 741 in informational display assist window 740 is highlighted so that the programmer is automatically reminded of the type, order, and details of the argument within the argument list.

- 5 Displaying the entire argument list, the present argument in highlighted form, and the details of each argument all within a single assist window is key to assisting the programmer toward quickly and accurately completing a procedure call type programming language statement. Displaying the argument list and highlighting the present argument eliminates the need for the programmer to
- 10 look up or remember the order, type, syntax, or substantive details of any argument. In alternative embodiments an optional argument can be noted by a distinguishing color or font type or any other distinguishing indicia other than square bracket enclosures.

- FIG. 8 illustrates procedure call 732 at time T2 with a first argument value
- 15 *Smith* 810 already in place. Note that in the present example the first argument 741 is a string type and because no previously declared values exist for this argument, the programmer must have manually typed the desired character string *Smith*. Pressing the Comma "," 811 commit key following the value *Smith* causes an update in the informational display assist window 740 so that the
- 20 second argument 742 is highlighted to indicate the present location of the character position cursor 732 within the argument list. Because the second argument 742 is a defined type comprised of three color members, a selection menu assist window 850 is generated and overlaid on the informational display assist window 740. The selection menu assist window 850 contains three menu
- 25 items 851-853 that the programmer can choose from to complete programming language statement 740 in a manner as previously disclosed in the text accompanying FIGs. 2-6. The selection menu assist window 840 is designed to disappear once a menu item is committed or the Escape key is pressed.

- FIG. 9 illustrates a time T3 where the second argument value *blue* 910
- 30 has been committed by using the Comma "," 911 commit key. The result of committing a value for the second argument 742 is that the assist window 740 is updated so indicate that the third argument 743 corresponds to the present location of the character position cursor within the argument list being

constructed in the procedure call 732. The third argument 743 is optional as indicated by the square brackets in the present example. A value for an optional argument can be committed or ignored as determined by the programmer. In the present example, because the third argument 743 has a default value "2", ignoring or failing to provide a value will result in the default value of "2" being used. However, if an alternative value is manually entered as in the present example where the value "5" is entered as the argument value 912, then the manually entered value is used in the procedure call 732. When values for each argument in procedure call 732 are present at a time T4, the informational display assist window 740 disappears.

Note that not only can a selection menu assist window overlay an informational display assist window as illustrated in FIG. 8, a second informational display assist window can overlay a first informational display assist window if one of the arguments in the first procedure call is itself a procedure call. As a value or menu item is committed or otherwise entered for each level of nested calls, the last active assist window is replaced with the next level of assist window. The number of nesting levels and/or combinations of assist windows are limited only by the programming language itself.

Another general use of an informational display assist window is when a programmer returns to a previously completed programming language statement and places the character position cursor somewhere within the programming language statement. By manually requesting information about the object entity on which the character position cursor rests, the statement building tool will display any information that is relevant to that point in the programming language statement. For example, if it is desirable for a programmer to review the value of a defined constant that is being used in a given programming language statement, then all the programmer must do is place the character position cursor within the characters of the defined constant and the constant's defined name and value are displayed in an informational display assist window. The statement building tool can determine the value of the defined constant by partial compilation. The statement building tool can determine that the object is a defined constant by reverse parsing the programming language statement.

Another use of an informational display assist window is to manually request a display of the menu items for an object entity within a programming language statement. A new menu item can be committed if desired to modify the programming language statement.

5 Operational Steps - FIGs. 10-13

FIGs. 10-13 illustrate the operational steps in flow diagram form for the statement generating and statement information tool. Specifically, FIG. 10 illustrates the statement generating tool overview in flow diagram form. FIG. 11 illustrates details of the automatic statement generating operational steps in flow diagram form. FIG. 12 illustrates details of commit key operational steps in flow diagram form. FIG. 13 illustrates details of manually requested assist window displays in flow diagram form.

The FIG. 10 overview starts at step 1008 and proceeds to step 1010 where the statement building tool initializes a programming language editing tool for use by the programmer. The programming language editing tool is a windows based application that has a multitude of user customizable operational options that each have a default setting if not modified by the user. The threshold option is whether the statement building tool's automatic operation feature is enabled or disabled. The operational options can include, but are not limited to, running the statement building tool with the automatic mode enabled or disabled, and defining custom hot-key combinations for manual statement building tool requests.

The automatic and manual features of the statement generating tool are accessed from branch point 1015 way of branches 1020 or 1030 respectively. Both the automatic and manual features can be activated and/or inactivated at any time by entering available hot-key or menu selection commands. Further, the automatic and manual features are not mutually exclusive and can therefore be used independently from each other or simultaneously with each other.

On the automatic feature branch 1020, if it is determined at decision step 1021 that the automatic statement building features are inactive, then no automatic statement building activities will occur and processing continues at step 1028. Alternatively, if it is determined at decision step 1021 that automatic statement building features are activated, then the automatic features begin their

continuous statement building processes at step 1023. Details of the automatic statement building operational steps are disclosed in the text accompanying FIG. 11.

If at decision step 1026 it is determined that it is desirable to inactivate the automatic features of the statement generating tool then the automatic features of the statement generating tool quit operating at step 1028. Alternatively, if it is determined at decision step 1026 that the automatic features of the statement generating tool will continue operating, then the automatic statement building tool remains active and processing continues at step 1023.

On the manual feature branch 1030, if it is determined at decision step 1031 that no manual statement building features are requested by the user, then processing continues at step 1038 without any action taken. Alternatively, if it is determined at decision step 1031 that manual statement building features are requested, then the requested manual feature is activated at step 1033. Details of the manual statement building operational steps are disclosed in the text accompanying FIG. 13.

If at decision step 1036 it is determined that no additional manual statement building requests exist, then the manual features of the statement generating tool quit operating at step 1038. Alternatively, if it is determined at decision step 1036 that additional manual statement generating tool requests exist, then manual statement building tool request processing continues at step 1033.

FIG. 11 illustrates the details of the automatic statement building operational steps from step 1023 of FIG. 10. Processing begins at step 1108 and proceeds to step 1110 where the automatic statement generating tool features are initialized and the tool begins a continuous symbol-level compilation of programming language statements that already exist and/or are being entered in real time. A symbol-level compilation is a high level compilation that resolves symbols, labels, aliases, and the like, but does not compile the programming language statements to the extent of generating machine executable object code. The purpose of a continuous-symbol-level compilation is to facilitate the real time availability of a set of object entities and/or other program related information that is based on previously defined programming language

statements, global symbols, accessible libraries, and/or other linked modules.

At step 1118, the statement generating tool waits for and reads the next character or command that is input by the user. A character includes any alphabetic, numeric, or special character that is part of a programming language statement. A command may be a character that is entered in a specific contextual situation, an administrative or window manipulation command, or a substantive feature command. Processing the input commands and/or character input comprise the remainder of the FIG. 11 operational steps.

If it is determined at decision step 1125 that a substantive statement generating tool feature command has been entered, then processing continues at step 1132. A substantive statement generating tool feature command is a programmer initiated request for a statement generating tool feature that can include, but is not limited to, a manually requested or on-demand assist window for a randomly selected programming language statement. Manual requests for statement generating tool features can be entered by way of a hot-key or command menu input. Hot-key commands can include any character or keystroke combination such as for example, {Ctrl-J}, {Ctrl-Shift-J}, {Ctrl-I}, {Ctrl-Shift-I}, and {Ctrl-Space}. The operational details of manual statement generating tool feature requests are disclosed in the text accompanying FIG. 13.

Once step 1132 processing is complete, processing continues at step 1118 as previously disclosed. Alternatively, if it is determined at decision step 1125 that the input received in step 1118 is not a substantive statement generating tool command, then processing continues at step 1141.

If it is determined at decision step 1141 that the input received in step 1118 is an administrative or window manipulation command, then processing continues to step 1145 where the command is interpreted and executed. At step 1149 the subject assist window and/or programming language editor window is refreshed as needed in response to executing the command, and processing continues at step 1118 as previously disclosed. Examples of administrative or window manipulation commands can include, but are not limited to, window navigation keys such as {Up}, {Down}, {PageUp}, {PageDown}, {Ctrl-PageUp}, {Ctrl-PageDown}, and {Escape}. Alternatively, if it is determined at decision step 1141 that the input received at step 1118 is not an

attempt by the statement building tool to modify or generate an assist window in the same manner as if the programmer had manually requested a statement generating tool feature by way of a command as identified in decision step 1125.

Thus whether responding to a manual or automatic command input, the statement generating tool executes substantially the same internal steps toward the end of modifying or generating an appropriate assist window. The set of automatic trigger characters that can force the automatic updating or generating of an assist window are typically programming language dependent and can be similar to or a subset of the set of commit keys previously discussed. The set of automatic trigger characters can include, but are not limited to the set of {Space,=,.,)+-*/<>}. Alternatively, if no modifications or new assist windows are required, then processing continues at step 1188.

If it is determined at decision step 1188 that automatic statement generating tool processing should continue, then processing continues at step 1118 where the system waits for another input character. Alternatively, if it is determined at decision step 1188 that no further automatic statement generating tool processing should continue, then processing continues at step 1190.

FIG. 12 illustrates the operational steps 1200 for committing an item from an assist window. The operational steps 1200 begin at step 1205 and are the details of step 1158 from FIG. 11. At step 1208 the selected menu item is committed. Committing a menu item results in replacing the word segment proximate the character position cursor with the selected menu item from the assist window and the assist window is removed. If it is determined at decision step 1210 that the input character from step 1118 of FIG. 11 is a non-delimiter type commit key for a present assist window item that was not a selected item, then processing continues at step 1220. Examples of a non-delimiter type commit key can include, but are not limited to, {Tab}, and {Ctrl-Enter}. An example of a present assist window item that is not also a selected item, is a lowlighted or broken-outline menu item in a menu selection assist window that is not highlighted. A highlighted menu item indicates that the menu item is not only the present menu item but also the selected menu item. At step 1220, the commit key that precipitated the immediate commit operation is discarded because it is not the type of character that is added to the programming

language statement itself. Processing then continues at step 1250.

Alternatively, if it is determined at decision step 1210 that the input character from step 1118 of FIG. 11 is a delimiter type commit key, then processing continues at step 1240. Examples of a delimiter type commit key can be programming language dependent and include, not be limited to, 5 {{Space} {Enter},{})+*/=<>!^}. An example of a present assist window item that is also a selected item, is a highlighted menu item in a menu selection assist window. A highlighted menu item indicates that the menu item is not only the present menu item but also the selected menu item. At step 1240, the commit 10 key itself is inserted into the programming language statement immediately following the previously inserted assist window item of step 1208.

If it is determined at decision step 1250 that new information exists that is relevant to the next segment of the programming language statement, then processing continues at step 1258 where the new information is displayed in an 15 update to a presently displayed assist window or in a newly generated assist window. Alternatively, if it is determined at decision step 1250 that no new information exists that is relevant to the next segment of the programming language statement, then processing continues at step 1254 where the presently displayed assist window is removed. In either case, processing 20 continues at step 1260 by returning to step 1132 of FIG. 11.

FIG. 13 illustrates the operational steps 1300 for processing a manual assist window request. The operational steps 1300 begin at step 1308 and are the details of step 1033 from FIG. 10 and step 1132 of FIG. 11. The assist window processing disclosed in text and FIG. 13 is substantially similar for the 25 automatic assist window processing as for the manually requested assist window processing. At step 1311, the type of processing required to satisfy the automated needs or the request made by the programmer identified by the hot-key combination used or other menu command selection. The type of processing required is directed to the appropriate processing steps at branch point 1320 by way of branches 1330, 1340, 1350, and 1360. 30

The operational steps on branch 1330 process informational menu assist window requests. In particular, branch 1330 processes the type of request that generates information relevant to a specific argument in a procedure call

manually requested procedure call argument list. The steps are substantially similar to the steps of branch 1330. However, the primary purpose of the branch 1340 steps is to generate a complete argument list regardless of the present location of the character position cursor within the programming language statement. Specifically, at step 1341 the programming language statement identified by the present location of the character position cursor is parsed into tokens. Central to the parsing of step 1341 is that not all procedure calls conveniently include parenthesis around the argument list as in *call procedure-name (arg1, arg2)*. A procedure call can also take the form of *procedure-name arg1, arg2*. For this reason, each token must be parsed and individually evaluated to accurately identify the procedure and its argument list.

The token representing the procedure identifier for the programming language statement is located at step 1344 by examining each token in the token list. If it is determined at decision step 1345 that the procedure identification token is not a symbol that can be resolved, then processing continues at step 1370. Alternatively, if it is determined at decision step 1345 that the procedure identification token is a symbol that can be resolved, then processing continues at step 1346.

At step 1346, the present argument token that is identified by the present character position cursor is located. The information obtained in steps 1341-1346 provide the procedure call name, the argument list, and the present argument that is highlighted to correspond with the present location of the character position cursor within the programming language statement. At step 1347, the compiler is invoked to bind against the set of known symbols and/or object entities for the argument list and an assist window is generated to display the information relevant to the procedure call and the present argument. Processing then continues at step 1370.

The operational steps on branch 1350 illustrate the steps for processing a manual request for an assist window that contains assignment information. Assignment symbol information includes, but is not limited to, symbols or constant lists that can validly follow the assignment symbol itself or any other arithmetic operator for example. At step 1351 the nearest operator is located that immediately precedes the present location of the character position cursor.

At step 1353, the object and member name token combination is identified that immediately precede the operator identified in step 1351. If it is determined at decision step 1354 that the token combination is not a symbol that can be resolved, then processing continues at step 1370. Alternatively, if it is determined at decision step 1354 that the token combination is a symbol that can be resolved, then processing continues at step 1355. The type of object and the return type of each member in the series is determined at step 1355.

If it is determined at decision step 1356 that the data type of the last property or method is an enumerated type, then the list of members of this enumerated type is generated and displayed in an assist window at step 1357. Processing continues at step 1370. Alternatively, if it is determined at decision step 1356 that the data type of the last property or method is not an enumerated type or other type that can be resolved based on presently available information, then processing continues to step 1358. At step 1358, a menu of possible choices is generated and displayed in a selection menu assist window. Processing then continues at step 1370.

The operational steps of branch 1360 illustrate the process of generating a member list resulting from a manual request. At step 1361, the programming language statement is parsed as previously disclosed. At step 1362, the compiler is invoked to bind the entire expression excluding the last identifier of the expression. At step 1365, a member list is assembled in view of the context of the remaining expression that includes the list of member functions and variables of the returned symbol. The generated list is displayed in a selection menu assist window. Note that the last identifier in the expression which was ignored for binding purposes, is identified in the assist window as the initial selection of the displayed member list. Processing then continues at step 1370.

Global lists and other miscellaneous lists are generated in a manner similar to the above argument lists, constant lists, and/or member lists as appropriate and in view of the symbol information that is available to the compiler at the time the request is made. For example, a reference to the symbol *VBA* in normal programming language code shows all callable procedures and all constants defined in the *VBA* library. However, the reference *As VBA* shows all types of defined in the *VBA* library. The resolved symbol

